Emotional and aesthetic antecedents and consequences of music-induced thrills

VLADIMIR J. KONEČNI, REBEKAH A. WANIC, AND AMBER BROWN
University of California, San Diego

The significance of music-induced thrills or chills was explored in 3 experiments ($N = 223$). Specifically, the ability of antecedent (priming) stimuli in different modalities and aesthetic domains (national anthems, stories, architectural objects, paintings) to increase the participants' thrills responsiveness to music by Rachmaninoff and Haydn was examined. In addition, the differential effects of having or not having experienced thrills on the participants' subsequent willingness to donate blood, and on their mood and self-concept, were tested. It was found that while the antecedent stimuli in different modalities could themselves induce thrills in a predictable manner, these priming stimuli, and the thrills they elicited, had relatively weak effects on the thrills subsequently induced by the Rachmaninoff and Haydn pieces. The measures of altruism, self-concept, and mood were not affected by either the antecedent variables or the thrills experience. Thrills may often accompany profound aesthetic experiences and provide their physiological underpinning, yet themselves be of limited psychological significance.

In the fast-growing body of research that addresses the relationship between music and emotion (cf. Juslin & Sloboda, 2001; Konečni, 2003), a certain amount of attention has been devoted to the fascinating phenomenon of *thrills* or *chills*. These terms refer to the shiver that usually starts at the back of the neck, with piloerection, and spreads down the back and arms, sometimes reaching other parts of the body. In his pioneering study, Goldstein (1980) surveyed 249 participants from three populations in Palo Alto, California (employees of the Addiction Research Foundation, medical students at Stanford University, and music students at Stanford University), about their experience of thrills and reported that about 75% of the respondents had indicated having experienced thrills at some point in the past—a number climbing to 90% for the music students. Sloboda (1991) identified 10 broad classes of structural elements in music that his participants reported as likely to induce thrills, including "harmonic or melodic acceleration to cadence" and "sudden dynamic or textural change." Panksepp (1995) noted that a

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solo voice emerging from an orchestral background was a likely chills-inducing candidate.

The phenomenological experience of thrills is unmistakable and can be reliably reported by participants, provided that precautions are taken to discourage over- and under-reporting. Panksepp (1998) observed that the experience of chills is accompanied by an increase in skin conductance (cf. Rickard, 2004), while Blood and Zatorre (2001), using positron emission tomography (PET), found an increase in cerebral blood flow in the brain areas that are generally associated with pleasure to correspond with the self-report of thrills induced by music. Goldstein (1980) used naloxone, an opiate-receptor blocker, to reduce the occurrence of music-produced thrills in 3 of 10 participants. Interestingly, whereas Goldstein's participants emphasized the importance of personal associations in mediating the effects of music on thrills, Blood and Zatorre (2001) reported that no such associations played a part. Considering that these researchers' participants—like Goldstein's and Rickard's—brought their own musical selections to the laboratory (ones that had reliably caused thrills in the past), it is perhaps odd that repeated exposures had not produced a wealth of personal associations. In the research we report here, the use of participant-selected music was intentionally avoided.

A considerable variability in the occurrence, intensity, and frequency of thrills in response to music has been noted—across participants to a given piece and within participants to the same piece on different occasions (Goldstein, 1980). For example, in the study by Blood and Zatorre (2001), the participants' control music pieces—to which, rather surprisingly (cf. Panksepp, 1995), no participant responded with even a single chill—were the very pieces that other participants had selected as especially chill-inducing. In our laboratory, after a great deal of pretesting, a number of pieces have been identified that reliably induce thrills in 30–50% of research participants. In several prior studies (Blood & Zatorre, 2001; Goldstein, 1980; Sloboda, 1991), most participants had 8 or more years of music training and included professional and amateur musicians. The present research used the general student population in order to increase the generalizability of the findings regarding the music-training dimension.

However, the main thrust of the exploratory work that we describe here is directed at what seems to us as the central problem, one that has been neglected to date: the psychological significance of thrills. Specifically, are there emotional, aesthetic, and social antecedents and consequences of the thrills that are induced by a piece of music? Can music-induced chills be primed by aesthetic and emotional events that precede the exposure to the thrill-inducing music? Do people feel and behave in measurably different ways after the experience of thrills? Most generally, to the extent that in Konečni's (2005, 2007) theory of the "aesthetic trinity" thrills are

considered to be the most common and least differentiated aesthetic response—the less common and more profound ones being the states of "being moved" and the peak experience of "aesthetic awe"—how do thrills fit in the stream of other encountered and experienced events?

With different degrees of explicitness, thrills have been considered as a notable emotional response by various researchers (e.g., Blood & Zatorre, 2001; Panksepp, 1995; Rickard, 2004; Sloboda, 1991). Yet none of these studies has demonstrated that the experience of thrills has either antecedents or consequences that one would expect of emotional states. In fact, it seemed to us possible that people's thrill response to music might not be primable by complex aesthetic and emotional stimuli, at least in the laboratory, and that the experience of thrills—even though it may accompany the cognitively and emotionally more complex states of being moved and aesthetic awe—is a primitive physiological phenomenon. Chills may be an evolutionary blind alley, one that does not lead to effects that can be reasonably expected as a consequence of a profound emotional experience—such as, for example, changes in mood and self-concept.

A considerable variety of independent and dependent variables was therefore used in this research, so that null findings could cumulatively be informative about the nature of chills. In three experiments, with some additional control conditions, the possible priming effects on music-induced thrills of three classes of stimuli were examined: music, stories, and visual-aesthetic. Note that some of these stimuli could be expected themselves to produce thrills, and this was explicitly investigated. In all three experiments, after the participants' exposure to thrill-inducing music (and their report of thrills), three additional sets of measures of theoretical interest were obtained: mood, prosocial self-concept, and prosocial behavioral inclinations.

Regarding mood, because prior researchers (e.g., Blood & Zatorre, 2001; Goldstein, 1980; Sloboda, 1991) described their participants' thrills experience as pleasurable, we expected that the participants' mood would improve in the course of the experiments—especially in the conditions that give rise to many thrills and in the participants who report thrills in both Segments A and B. However, such a prediction should not be understood as acknowledging thrills as a genuine emotional state, for we (Konečni, 2007; Konečni, Brown, & Wanic, in press), along with others (e.g., Scherer & Zentner, 2001), sharply distinguish between mood and emotion.

Konečni (2005) noted that people may feel privileged to have gained access to a sublime stimulus. Analogously, those who are moved by stories of self-sacrifice, or those experiencing thrills in response to their national anthem or a piece by Rachmaninoff, may show a positive change in self-concept, specifically on the prosocial dimension that includes generosity

and helpfulness (Brown & Mankowski, 1993; Haidt, 2000). Measures of one's self-reported propensity for generosity and helpfulness were taken in Segment C to test whether differences could be found between participants who had experienced thrills and those who had not.

There is some evidence that listening to music may increase one's willingness to be helpful to others (Fried & Berkowitz, 1979). In addition, the witnessing of acts of selfless sacrifice is presumed by Haidt (2000) to increase the witness's desire to perform positive acts. We explored such ideas in the present research by investigating the participants' willingness to donate blood and tutor underprivileged children as a function of experiencing music-induced thrills.

To summarize, each of the three experiments consisted of three segments: Segment A, priming (with a measure of thrills induced by the priming stimuli themselves); Segment B, exposure to thrill-inducing music (by Rachmaninoff or Haydn), with a measure of thrills; and Segment C, measurement of the effects of previously experiencing vs. not experiencing thrills on mood (sad–happy; depressed–elated), prosocial self-concept (generosity, helpfulness), and behavioral inclinations (willingness to donate blood and tutor disadvantaged children).

EXPERIMENT 1: MUSIC (NATIONAL ANTHEMS)

Anecdotal evidence suggests that the national anthem of a particular country is a powerful cause of thrills for many citizens of that country—but of no other. Because of such specificity, it can be safely assumed that an anthem's effect is not produced just by its musical structural elements. In Experiment 1, the Australian national anthem served as the control for the U.S. anthem in our attempt to test whether anthem-induced thrills increase receptivity to the thrill-inducing attributes of subsequently heard pieces by Rachmaninoff and Haydn.[1]

METHOD

Participants

Eighty-two University of California, San Diego (UCSD) students ($M = 19.6$ years of age, $SD = 1.31$), 60 women and 22 men, most of whom were presumably U.S. citizens, were recruited through a sign-up roster and received credit in psychology courses. Ethnic categorization indicated that 47 were Asian, 25 Caucasian, 6 Middle Eastern, and 4 Hispanic.

Equipment and experimental materials

Instructions and music files were digitally recorded and transferred to compact discs in the sequence appropriate for various experimental conditions. Partici-

pants heard the instructions and the music at a standard volume level through Sennheiser HD 500 headphones from a JVC XL-R 2010 compact disc player. All music selections were instrumental: Sergei Rachmaninoff, Piano Concerto No. 2, third movement (the last 4'30"), pianist Stephen Hough, Dallas Symphony Orchestra, Andrew Litton, conductor; Joseph Haydn, Symphony No. 102, 4'56" from the third movement, Capella Istropolitana, Barry Wordsworth, conductor; U.S. national anthem, 1'34"; as an additional control, Jimi Hendrix's idiosyncratic 1969 version of the U.S. anthem at Woodstock, 2'20"; and Australian national anthem, 2'00".

Procedure and design

Participants arrived singly at an anteroom where informed consent was obtained and then sat at a table perpendicular to the experimenter's, 135 cm away, in a spacious laboratory with comfortably dim lighting. Twelve experimenters were used (11 female). The participant put on headphones and was asked to fill out an introductory questionnaire while listening to music. In all conditions, the experiment began with a 13'20" track of bland, relaxing music during which the participant worked on a 10-page questionnaire. After finishing it, the participant continued to relax while awaiting further instructions.

Warm-up questionnaire. The questionnaire consisted of 28 items dealing with demographic and student-life information. Its main purpose was to draw attention away from the three scales of main interest. These included a scale of current mood (scale ends: "I feel sad" and "I feel happy"), emotional reactivity ("I react with a lot of emotion to the major events in my life"), and emotional physical sensation ("I 'feel' my emotions as a physical sensation"); the anchors for the latter two scales were *agree completely* and *disagree completely*. Responses on all scales (unnumbered, 13-point) were recorded by circling the appropriate tick mark. Scale ends were counterbalanced across participants and conditions.

Segment A. When the warm-up track ended, the participants were informed that they would hear some music next. They were requested to report thrills or chills—described as "a spreading shiver down the spine, a tingling on the back of the neck or arms, or goose bumps"—by slightly raising their hand off the table top at any time during all subsequent musical pieces, beginning with when they felt the thrill, and leaving it raised until the sensation subsided (cf. Goldstein, 1980).[2] It was emphasized that both feeling and not feeling thrills is natural for both women and men; participants were urged not to report chills if they experienced none. The musical selection appropriate to the condition to which the participant had been randomly assigned then began: the U.S. anthem (in three conditions), or Hendrix's version, or the Australian anthem.

Segment B. The purpose of this segment was for the participants in six (of the total of eight) conditions to hear thrill-inducing music, either Rachmaninoff or Haydn. In four of these six conditions, participants heard music in both Segments A and B: U.S. anthem followed by Rachmaninoff ($n = 10$), Hendrix's version followed by Rachmaninoff ($n = 10$), Australian anthem followed by Rachmaninoff ($n = 10$), and U.S. anthem followed by Haydn ($n = 10$). In these conditions, the Segment A piece was followed about 5 s later by Rachmaninoff or Haydn. In two control conditions, Segment A was entirely omitted and the instructions for re-

porting chills were followed directly by Rachmaninoff or Haydn (*n*s = 10 and 12, respectively). There was also a control condition in which the Segment B music was omitted and the U.S. anthem was followed immediately by the Segment C measures ($n = 10$). In the final control condition, both of the first two segments were omitted and Segment C began directly after the warm-up track concluded ($n = 10$). In all seven conditions involving some listening to music, the experimenter noted each occasion when a participant raised and lowered a hand, so that both the number and the duration of thrills were recorded.

Segment C. After the participant's headphones were removed, the dependent measures were collected. To begin, one of two prosocial behavioral-inclinations scales (willingness to donate blood or to tutor children) was presented. To increase credibility, the experimenter said she was acting on behalf of either the San Diego County Blood Bank or the San Diego County Public Schools. Responses were given by circling the appropriate tick mark on 13-point unnumbered scales with ends *highly willing* and *highly unwilling*. After this rating, the experimenter presented the participant with two self-report scales pertaining to mood and two to the prosocial self-concept. The items and scales were: "Please indicate how you are feeling at this moment" (very sad–very happy); "I would describe my mood right now as . . ." (depressed–elated); "I am helpful when I see other people in need" (highly disagree–highly agree); and "I consider myself generous in my interactions with other people" (highly disagree–highly agree). Answers on all 13-point unnumbered scales were recorded by circling the appropriate tick mark. The experimenter then discussed the student's music taste, and—under the pretense of forgetting to ask earlier—she presented the second prosocial scale. Each participant was then debriefed and thanked.

RESULTS AND DISCUSSION

Thrills in Segment A

The participants' chills responsiveness to the musical stimuli in Segment A is presented in the top part of Table 1. A total of 11 out of 50 people (22%) reported thrills to the three anthems considered together. Eight of these people were among the 30 participants in the three conditions in which the authentic U.S. anthem was heard; in comparison, 2 of 10 participants responded to Hendrix's version and only 1 to the Australian anthem. This pattern of results was precisely as predicted, but the differential effect of the three anthems was not strong enough, $\chi^2(2, N = 50) = 1.24$, *ns*. The 11 thrill-experiencing participants reported a total of 22 individual thrill occurrences, 17 of which were felt by the 8 participants who heard the U.S. anthem. The pattern for the mean number of thrills in the three experimental conditions (second data column in Table 1) was identical to that for the percentage of participants reporting thrills, but $F(2, 47) < 1$. And as can be seen in the third data column in Table 1, the pattern for the mean duration of thrills by experimental condition, across all 50

Table 1. Segment A thrills

Segment A stimulus	Percentage of participants reporting thrills	Mean number of thrills	Mean duration of thrills (s)
		Experiment 1	
U.S. anthem[a]	26.67	0.57 (1.04)	2.07 (5.09)
Jimi Hendrix[b]	20.00	0.30 (0.68)	1.70 (5.03)
Australian anthem[b]	10.00	0.20 (0.63)	0.60 (1.90)
		Experiment 2	
Positive-end story[c]	9.68		
Negative-end story[d]	40.00		
Neutral story[b]	0.00		

Note. Numbers in parentheses are standard deviations.
[a]$n = 30$. [b]$n = 10$. [c]$n = 31$. [d]$n = 20$.

participants, matches the patterns for the other two thrills measures, but $F(2, 47) < 1$.

Thrills in Segment B

Various measures of thrills experienced in Segment B by the participants in four conditions of Experiment 1 are presented in the top section of Table 2. Data for the two control conditions, which are relevant for all three experiments, are presented at the bottom of Table 2. Was there a priming effect of the thrills response to music by prior music? The answer to this question in Experiment 1 is negative. Of the 40 participants who heard music in Segment A, 12 (30%) reported thrills in Segment B to Rachmaninoff or Haydn, whereas of the 22 participants who heard one of these Segment B pieces without previously hearing any music, 8 (36%) reported thrills to them, $\chi^2(1, N = 62) < 1$. Similar results were obtained when the mean number and the mean duration of thrills were analogously contrasted, $t(60) < 1$ in both cases.

The next question to consider is whether there was a priming effect of thrills by thrills—within the same, music, modality, but with radically different music that is heard on successive occasions. The answer is negative. Of the 10 participants who had reported thrills in Segment A, 4 did so again in Segment B; 8 people who had not previously experienced thrills reported them in Segment B; and 22 participants reported thrills on neither occasion. In short, experiencing thrills to one of the anthems did not increase the probability of experiencing them to Rachmaninoff or Haydn, $\chi^2(1, N = 40) < 1$.

The final issue that needs to be addressed is whether the three music stimuli in Segment A had differential effects on the various chills measures

Table 2. Thrills in Segment B as a function of Segment A stimuli

	Segment B musical piece					
	Rachmaninoff			Haydn		
Segment A stimulus	Percentage of participants reporting thrills	Mean number of thrills	Mean duration of thrills (s)	Percentage of participants reporting thrills	Mean number of thrills	Mean duration of thrills (s)
U.S. anthem	20.00	0.50 (1.08)	1.10 (2.85)	10.00	0.70 (2.21)	1.60 (5.06)
Jimi Hendrix	30.00	0.50 (0.97)	3.80 (10.32)			
Australian anthem	60.00	1.90 (1.91)	13.90 (20.06)			
Positive-end story	45.45	0.91 (1.30)	1.91 (2.47)	30.00	0.30 (0.48)	0.30 (0.48)
Negative-end story	40.00	1.00 (1.63)	4.00 (7.27)	20.00	0.20 (0.42)	0.20 (0.42)
Neutral story	40.00	1.60 (2.41)	5.50 (10.3)			
Pyramids	40.00	0.90 (1.28)	3.90 (6.94)	20.00	1.00 (2.31)	4.70 (11.78)
U.N. building	20.00	1.10 (2.60)	1.60 (3.50)	10.00	1.00 (3.16)	1.10 (3.48)
Mona Lisa	50.00	1.00 (1.24)	2.80 (4.21)	20.00	0.20 (0.42)	0.40 (0.97)
Maddalena Strozzi	40.00	0.70 (1.06)	2.50 (4.38)	10.00	0.10 (0.32)	0.60 (1.9)
No Segment A stimulus	40.00	0.90 (1.37)	4.70 (8.58)	33.33	0.42 (0.67)	0.83 (1.75)

Note. $n = 10$ in all Segment A conditions, except positive-end story/Rachmaninoff, where $n = 11$, and no Segment A stimulus/Haydn, where $n = 12$. Numbers in parentheses are standard deviations.

during the exposure to Rachmaninoff (see Table 2). Here, the answer is largely positive and unexpected. The percentage of people who responded with thrills to Rachmaninoff after hearing the Australian anthem (60%) was greater (though not significantly so) than was the case for people who had previously heard either the authentic U.S. anthem (20%) or Hendrix's version (30%), $\chi^2(2, N = 30) = 3.72$, $p = .15$. More conclusively, analysis of variance (ANOVA) comparisons of these three conditions in terms of the mean number and mean duration of chills showed strong analogous effects: Listening to the Australian anthem in Segment A, as opposed to the U.S. anthem or Hendrix's version, resulted in significantly more thrills being felt by the participants to Rachmaninoff in Segment B, $F(2, 27) = 3.40$, $p < .05$, and the thrills were of considerably longer duration, $F(2, 27) = 4.06$, $p = .025$.

Segment C Measures

The results obtained in Segment C will be discussed in a separate section, after the presentation of all three experiments.

In sum, to the extent that their reports were veridical, and every effort was made to ensure it, participants experienced chills even in the sterile laboratory setting; the effect of the anthems on all measures of thrills was in the predicted direction (the U.S. anthem > Hendrix > the Australian anthem), though not statistically significant; neither listening to music nor experiencing thrills primed the subsequent thrills-responding to music; and, interestingly, the weakest thrill-inducing stimulus in Segment A, the Australian anthem, had significantly more impact than the U.S. anthem and Hendrix's version on two of the three measures of Rachmaninoff-induced thrills (this issue will be addressed in the General Discussion).

EXPERIMENT 2: STORIES (SELFLESS SACRIFICE)

According to Konečni (2005), the state of *being moved* (cf. Scherer & Zentner, 2001), accompanied by thrills, can be induced by both aesthetic and nonaesthetic stimuli. Among the latter, perhaps the prototypical case is the occurrence of acts of selfless sacrifice. Haidt (2000; cf. Keltner & Haidt, 2003) called the state resulting from witnessing such acts "the positive emotion of elevation." Thrills have been explicitly associated with such contexts by Goldstein (1980). A literary story in which selfless acts of sacrifice are described is a combination of aesthetic and nonaesthetic means of producing the state of being moved and thrills. In one condition of Experiment 2, participants read about shipwrecked adults who sacrificed their food and water so that a little girl (to whom they were not related) would live. In another condition, the girl died despite the efforts. Altruistic behavior

that is not "successful" ought to be less likely to lead to Haidt's (2000) "elevation," but may nevertheless be moving or touching. The control was a bland description of an uneventful sea voyage. The possible differential effect of reading the story versions (and the chills they caused) on the subsequent music-induced thrills was investigated.

METHOD

Participants

Sixty-one UCSD students ($M = 20.0$ years of age, $SD = 1.58$), 53 women and 8 men, were recruited in the manner described in Experiment 1. Ethnic categorization indicated that 25 were Asian, 20 Caucasian, 11 Hispanic, 3 Middle Eastern, and 2 "other."

Experimental materials

A section of Graham Greene's (1948) novel *The Heart of the Matter* was modified. In a self-contained episode, an account is given of a capsized ship and the survivors' efforts during a 40-day ordeal in a lifeboat to save a 6-year-old girl to whom they are not related, while they themselves die of thirst. In the "positive-end" version, the participants learned in the final paragraph that the girl survived, whereas in the "negative-end" story they read that she died. The control version was a bland description of a sea voyage. The stories' length ranged from 494 to 519 words and took about 5 min to read.

Procedure and design

Segment A. The initial treatment of participants was identical to that in Experiment 1. After the warm-up music, the participant was asked to read a story at a normal pace and to report any thrills experienced during the reading. Once it was completed, the experimenter noted whether or not the participant had raised a hand.

Segment B. Participants were informed that they would listen to music and asked to report any chills. The time of each hand raising and lowering was noted. Participants were randomly assigned to one of six conditions defined by the story version and the musical selection: Each of the three story versions was followed by Rachmaninoff; the positive- and negative-end versions were also paired with Haydn; and in the sixth condition, Segment B was omitted and Segment C followed the positive-end story directly. There were 10 participants per condition (11 in the Positive-end/Rachmaninoff condition).

RESULTS AND DISCUSSION

Thrills in Segment A

The participants' thrills responsiveness to stories in Segment A is presented in the lower part of Table 1. Eleven of 61 people (18%) reported thrills

to the three story versions considered together. A test of the hypothesis that reading a story depicting selfless sacrifice (positive- and negative-end versions) would produce more thrills than would reading the neutral story was strongly born out by the data, $\chi^2(2, N = 61) = 10.19$, $p = 0.006$.

However, contrary to the hypothesis that self-sacrificial behavior that was successfully life-saving would induce more chills than the same behavior that failed to save life, the negative-end story induced thrills in a significantly greater proportion of participants than did the positive-end version, $\chi^2(1, N = 51) = 6.61$, $p = .01$. Although it is true that in Greene's novel death conquers life, artistic merit is unlikely to be responsible for the result because the versions differed minimally. It seems instead that separation and loss—discussed by Panksepp (1995, 1998) as important sources of chills—can induce them more readily than can the positive state of elevation (Haidt, 2000).

Thrills in Segment B

Various measures of thrills experienced in Segment B by the participants in five conditions of Experiment 2 are presented in the middle part of Table 2. Was there a priming effect of the thrills response to music by prior exposure to literature? The answer is negative. Of the 51 participants who read a story in Segment A, 18 (35%) reported thrills in Segment B, whereas of the 22 participants who heard the musical pieces without previously being exposed to any stimuli, 8 (36%) reported thrills. As is clear from Table 2, the result was no different when just the four positive- and negative-end story conditions (14 people of 41, 34%, experiencing thrills) were compared with the two control groups. Furthermore, similar results were obtained for the analogous contrasts in terms of both the mean number and duration of thrills, all *t*s nonsignificant.

The next question to consider is whether there was a priming effect of thrills by thrills across different successive thrill-inducing modalities, from stories to music—and the answer is negative. Of the 11 participants who had reported thrills in Segment A, only two did so again in Segment B; 16 people who had not previously experienced thrills reported them in Segment B; and 24 participants reported thrills on neither occasion. Therefore, feeling thrills in response to a literary text did not increase the probability of feeling them to Rachmaninoff or Haydn, $\chi^2(1, N = 51) = 1.80$, *ns*.

The final question to be addressed is whether the three story versions in Segment A had differential effects on the three thrills measures in Segment B. On the measure of the number of people experiencing thrills, the overall test, $\chi^2(3, N = 51) = 1.86$, as well as the ones on the effects of the three story versions, $\chi^2(2, N = 51) < 1$, and of Rachmaninoff versus Haydn, $\chi^2(1, N = 51) = 1.53$, were all nonsignificant.

In order to examine the effects of the story versions on the mean number and mean duration of thrills, three sets of analyses were carried out. In the first set, 2 × 2 (positive- vs. negative-end stories × Rachmaninoff vs. Haydn) ANOVAs were performed on the two dependent measures. In both cases, only a main effect of music piece was found, such that Rachmaninoff produced significantly more thrills and longer thrills than Haydn, $F(1, 38) = 4.21$, $p < .05$ and $F(1, 38) = 5.12$, $p = .03$, respectively. The main effect of story version and the interaction were negligible on both measures, $F(1, 38) < 1$ for all tests. After a depiction of self-sacrifice at sea, a passionate Romantic piece of music was a more powerful thrill inducer than a restrained Classical one.

In the second set, the effects of the four conditions in which the participants heard Rachmaninoff (see Table 2) were compared in one-way ANOVAs. Overall Fs(3, 37) were nonsignificant for both measures. In view of the surprising Segment B Rachmaninoff results in the Australian anthem condition in Experiment 1, it was notable that the greatest mean number (1.60) and mean duration (5.50 s) of thrills to Rachmaninoff in Experiment 2 were recorded for the participants who had previously read the bland, non–thrill-inducing, neutral story (Table 1), followed—in terms of the mean duration measure (4.70 s)—by those who had read nothing at all before listening to music (however, the relevant contrasts were not statistically significant).

In the third set of analyses, the effects of the three conditions in which the participants heard Haydn (see Table 2) were compared in one-way ANOVAs. Overall Fs(2, 29) were nonsignificant for both the number and duration of thrills. The participants who had read nothing prior to listening to Haydn experienced longer thrills, on the average (0.83 s), than those who were exposed to accounts of self-sacrificial behavior (0.25 s), but this interesting contrast was nonsignificant.

In sum, participants experienced chills after reading self-sacrificial stories: negative-end story > positive-end story > neutral story. We believe that this has not before been experimentally demonstrated. However, reading stories and feeling chills to them did not prime the subsequent chills responding to music. Significantly more and longer chills were felt by the participants to Rachmaninoff than to Haydn after reading either the negative- or the positive-end story. Finally, the weakest chill-inducing stimulus in Segment A, the neutral story, had a greater (albeit not significantly so) impact than both the negative- and positive-end versions on two measures of chills in the subsequent responding to Rachmaninoff; analogously, the participants who had previously not read anything responded with longer chills to Haydn than did those who had read the self-sacrificial stories. These issues will be readdressed in the General Discussion.

EXPERIMENT 3: VISUAL-AESTHETIC STIMULI (PYRAMIDS, PAINTINGS)

Konečni (2005) suggested that aesthetic awe is the peak human aesthetic experience, a response to a sublime stimulus-in-context. The latter is of great beauty, exceedingly rare, of colossal size, and often difficult to reach (among other criteria). The pyramids of Giza are prototypic sublime stimuli, but slides obviously do not do them justice.[3] Nevertheless, it was of interest to explore whether the image of a Giza pyramid might have a priming effect on the thrills response to Rachmaninoff—even though it was not expected that the contextless image would itself induce thrills. Other images were used as controls for the sublime attributes and real-world size: the United Nations building in New York, well known and some 20 m higher than Cheops but far from sublime (in pretesting); Leonardo's *Mona Lisa*—famous, beautiful (in terms of both painterly qualities and the woman's appearance), but small in reality; and *Maddalena Strozzi* by Raphael: painted at the same time (very early 1500s) and place (Florence) as *Mona Lisa*, with the model (far less attractive, according to pretesting) in a similar pose—a painting as well executed but far less famous. All images were followed by both Rachmaninoff and Haydn. Because it was expected that Haydn would induce chills in fewer participants than would Rachmaninoff, the design allowed a test of the effects of Segment A visual-aesthetic stimuli on Segment C measures in participants with a different interpolated thrills experience.

METHOD

Participants

Eighty UCSD students ($M = 20.4$ years of age, $SD = 3.88$), 61 women and 19 men, took part. Ethnic categorization indicated that 39 were Asian, 23 Caucasian, 9 Hispanic, 6 Middle Eastern, and 3 "other."

Equipment and experimental materials

Five slides were used: *Mona Lisa* (Leonardo da Vinci, 1503–1506, actual size 77 × 53 cm); Pyramids of Giza, Egypt, specifically Cheops (actual height 146.5 m, color photograph by V. J. Konečni, 1979) and Chephren (actual height 143 m, sepia photograph by Carolyn Brown, 1980); the United Nations Secretariat Building (actual height 166 m, architects Wallace Harrison, Le Corbusier, et al., 1950; color photograph by N. McGrath, 1999); and *Maddalena Strozzi* (Raphael/Raffaello Sanzio, 1505–1506, 63 × 45 cm). The slides were projected by a Kodak Carousel 5600 projector onto a standard screen (Bretford 300 Spectator) that was 544 cm away. The size of the screen image was 146 × 98 cm in the portrait orientation.

Procedure and design

The participant was seated at a desk, 315 cm away from the screen, and randomly assigned to one of eight conditions ($n = 10$): Each of the four images—Cheops (or Chephren) Pyramid, the U.N. building, *Mona Lisa*, *Maddalena Strozzi*—was paired with both Rachmaninoff and Haydn. In the Pyramid condition, half of the participants saw Cheops and the other half saw Chephren.

Segment A. Following the warm-up music, participants received instructions that they would be viewing a slide, first in silence and then accompanied by music. They were requested to report any chills that occurred during the presentation of the slide and the music. One of the five slides was then projected onto the screen; the participant viewed it in silence for 45 s.

Segment B. After the slide was on for 45 s, the participant heard music through the headphones. The image stayed on until the music's conclusion. Thus, the slide was presented continuously for 4'55" to the participants listening to Rachmaninoff and for 5'21" to those listening to Haydn. Segment C ensued.

RESULTS AND DISCUSSION

Thrills in Segment A

The thrills instructions in Experiment 3 were identical to those in Experiments 1 and 2. Nevertheless, in Experiment 3, not a single participant reported a thrill to an image during its 45 s exposure before the beginning of Segment B music. One reason for this may have been an unforeseen procedural artifact: Because the participants were informed that the image would imminently be accompanied by music, they may have suspended reports to the slide alone. The absence of thrills in Segment A of Experiment 3 is, however, reassuring in one sense: It seems unlikely that the thrills responding in Experiments 1 and 2 to the music and story stimuli was due to experimenter demand alone. The complete absence of reported thrills to the neutral story in Segment A of Experiment 2 (Table 1) supports such a conclusion.

Thrills in Segment B

Various measures of thrills experienced in Segment B by the participants in the eight conditions are presented in the bottom part of Table 2. Did the exposure to visual-aesthetic stimuli in Segment A increase the participants' thrills responsiveness to Rachmaninoff and Haydn in comparison to the control conditions? The answer is negative: Of the 80 participants who saw an image in Segment A, 21 (26%) reported thrills in Segment B to Rachmaninoff or Haydn, whereas of the 22 participants who heard these musical pieces without previously being exposed to any stimuli, 8 (36%) reported thrills to them, $\chi^2(1, N = 102) < 1$. Similar results were obtained for analogous contrasts in terms of the mean number and duration of thrills, both *t*s ($df = 100$) nonsignificant.

One way to understand the fact that aesthetic-visual stimuli, if anything, lowered the participants' thrills responsiveness to music is by considering prior research that has shown complex interactive effects of the simultaneously presented paintings and classical music (e.g., Konečni, 1995). In Experiment 3, the image, after being seen alone, remained and then accompanied the music, which raises the possibility that it became a distractor (cf. Konečni & Sargent-Pollock, 1976) that dampened the music's impact. In fact, attentional focus on the sublime stimulus is an integral part of the aesthetic-trinity theory (Konečni, 2005). Such considerations illustrate the complexities in this area of research.

The final question is whether the four images in Segment A had differential effects on the number of participants who experienced thrills while listening to Rachmaninoff (15 of 40, 37.5%) and Haydn (6 of 40, 15%), and on the mean number and duration of thrills. The finding of an overall 4×2 test of whether the proportion of people experiencing thrills differed as a function of image seen and music heard was weak, $\chi^2(4, N = 80) = 7.89$, $p = .096$, and there was no difference between the effects of the four images, $\chi^2(3, N = 80) = 2.26$, *ns*; however, a significantly greater proportion of people listening to Rachmaninoff felt thrills than of those listening to Haydn, $\chi^2(1, N = 80) = 5.23$, $p = .02$. In contrast, the 4×2 ANOVAs on the mean number and duration of chills revealed no statistically significant effects, including that of Rachmaninoff versus Haydn, all Fs < 1.

In sum, no participants reported thrills in response to visual-aesthetic stimuli; viewing images did not overall or differentially affect the number of people feeling thrills to the subsequent (and simultaneous) music, nor were there any significant effects on the number and duration of thrills; and, as in Experiment 2, the participants' thrills response to Rachmaninoff was significantly more pronounced than to Haydn.

EXPERIMENTS 1–3: SEGMENT C MEASURES

Extensive analyses were carried out on the dependent measures of mood, prosocial self-concept, and prosocial behavioral inclinations that were collected in the final part of all three experiments.

Mood

In all 22 experimental and control conditions, the 223 participants responded on the sad–happy (1–13) scale both in the warm-up questionnaire and in Segment C; the respective grand means were 7.94 ($SD = 2.27$) and 8.42 (1.93), and the correlation .63 ($p < .0001$). As measured by this central mood scale, the participants' state improved as a function of the totality of the events in the three experiments, $t(221) = 3.87$, $p = .0001$. In addition,

when the two control conditions in which Segment A was omitted were contrasted with the baseline condition in which both Segments A and B were omitted, there was a marginally significant improvement in the participants' mood due to listening to Rachmaninoff ($M = 9.1$, $SD = 1.37$) and Haydn ($M = 9.5$, $SD = 1.93$) as opposed to no music at all ($M = 8.25$, $SD = 1.32$), $t(30) = 1.78$, $p = .09$.

However, the participants' mood was not changed differentially on the sad–happy scale or on the depressed–elated scale (used only in Segment C; $GM = 8.03$, $SD = 1.81$), either by the three experiments or by the conditions within them: Those that were superior in thrill induction (anthems and stories) fared no better at improving mood than did the conditions (aesthetic-visual images) that were inferior in thrill induction. The improvement in the participants' mood is statistically significant both for the 75 people (34%) who experienced thrills at some point in the experimental session ($M = 7.85$ to 8.65), $t(74) = 3.49$, $p = .0008$, and for the 147 (66%) who did not experience a thrill at any time (from $M = 7.99$ to 8.3), $t(146) = 2.18$, $p = .03$.

In sum, the experience of chills was not associated with either the participants' preceding, or their subsequent, mood. The sad–happy self-ratings improved in the experiments, but not as a function of identifiable manipulations or of the experience of chills.

Prosocial self-concept

The participants thought of themselves as helpful ($GM = 10.33$, $SD = 1.70$) and generous ($GM = 9.97$, $SD = 1.66$) individuals ($r = .64$, $N = 222$, $p < .0001$) across all conditions (see Table 3). However, neither of these self-ratings was differentially affected by the three experiments overall, nor by the specifics of the conditions within the individual experiments. For instance, listening to the U.S. anthem did not result in higher self-ratings than did listening to the Australian one (see Table 3: for helpfulness, $F(2, 47) = 1.47$, *ns*; for generosity, $F(2, 47) < 1$). Also, there were no differences among the three story versions in their effects on either self-rating (see Table 3; for both helpfulness and generosity, $F(2, 58) < 1$).

In view of the lack of differential effects of the various thrill-inducing manipulations, it is not surprising that experiencing thrills was not significantly associated with higher ratings on the scales of generosity and helpfulness; this was so across all 22 conditions, as well as in terms of the three separate experiments.

Prosocial behavioral inclinations

The grand means for the willingness to tutor children (9.78, $SD = 2.84$) and, especially, to donate blood (8.18, $SD = 4.00$) were smaller than those for the prosocial trait ratings (see Table 3), and in 20 of 22 conditions the mean for tutoring was larger than for blood donation—a pattern reflecting

Table 3. Segment C means as a function of Segment A stimulus

Segment A stimuli	Helpfulness	Generosity	Tutoring	Blood donation
U.S. anthem[b]	10.42 (1.82)	10.03 (1.71)	10.27 (2.23)	7.87 (3.93)
Jimi Hendrix[c]	11.40 (1.17)	10.25 (1.99)	10.90 (1.73)	7.90 (3.87)
Australian anthem[c]	10.90 (1.29)	10.60 (2.07)	9.80 (2.10)	7.90 (4.07)
Positive-end story[d]	9.94 (1.57)	9.71 (1.69)	9.94 (2.58)	8.48 (4.40)
Negative-end story[a]	10.10 (1.37)	9.60 (1.14)	9.60 (3.02)	8.84 (3.47)[e]
Neutral story[c]	10.40 (2.22)	10.20 (1.93)	10.30 (2.63)	9.40 (3.89)
Pyramids[a]	10.50 (2.33)	10.40 (1.39)	10.15 (3.33)	9.30 (3.71)
U.N. building[a]	10.20 (1.06)	9.75 (1.29)	8.55 (3.03)	7.90 (4.25)
Mona Lisa[a]	10.23 (1.58)	10.13 (1.57)	8.83 (3.10)	7.27 (3.35)
Maddalena Strozzi[a]	9.95 (2.04)	9.60 (2.09)	9.50 (3.80)	9.05 (4.16)

Note. Entries in columns 2–5 are mean ratings on 1 (*low*) to 13 (*high*) scales; numbers in parentheses are standard deviations.
[a] $n = 20$. [b] $n = 30$. [c] $n = 10$. [d] $n = 31$. [e] $n = 19$.

realism in the participants' self-concept and a responsible treatment of the rating scales. Therefore, if in the case of helpfulness and generosity one might have entertained the possibility of a ceiling effect as an explanation of the lack of significant effects, this will not do for blood donation. Of course, such reasoning neglects the ambivalence with which many people approach blood donation—and this was lawfully reflected in the data: In 19 of the 22 conditions the standard deviation for tutoring underprivileged children was smaller than the one for blood donation.

The one-way ANOVAs for the 22 conditions were not significant for either tutoring, $F(21, 201) < 1$, or blood donation, $F(21, 200) = 1.42$, $p = .11$. In addition, neither of these self-ratings of altruistic behavioral inclination was differentially affected by the three experiments or the conditions within them. For example, any patriotic sentiment that may have been activated by hearing the U.S. anthem did not translate into a greater propensity for donating blood: The contrast of the U.S. anthem, Hendrix's version, and the Australian anthem resulted in $F(2, 47) = 0.00$, $p = 1$ (see Table 3; the same contrast for tutoring yielded $F(2, 47) = .69$).

The choice of blood donation and tutoring was influenced in part by the notion that reading about sacrifice would induce "elevation" (Haidt, 2000) that could be captured on these scales. However, there were no differences among the three story versions on either measure: For tutoring, $F(2, 58) < 1$; for blood donation, $F(2, 57) < 1$. The mean for the neutral story was actually the largest in both cases (see Table 3).

As for Experiment 3 (Table 3), in the 4 (visual images, between-Ss) × 2 (tutoring vs. blood donation, within-Ss) ANOVA, the main effects of images, $F(3, 76) = 1.70$, $p = .17$ (biggest means in the Pyramids condition), the main effect of the type of prosocial behavioral inclinations, $F(1, 76) = 2.86$,

$p = .10$ (tutoring > blood donation), and the interaction, $F(3, 76) < 1$, were all nonsignificant. The planned contrast between the two Pyramids and two U.N. building conditions—showing that those who viewed the pyramids were more willing to tutor disadvantaged children and donate blood than those who viewed the U.N. building (see Table 3)—resulted in (one-tailed) $t(38) = 1.69$, $p = .05$.

Turning to the central issue: Experiencing versus not experiencing thrills was not differentially associated with self-ratings on either of the two scales—both across and within experiments. However, with regard to blood donation only, and in terms of all 22 conditions and both Segments A and B, there was a marginally significant relationship, $\chi^2(2, N = 222) = 5.02$, $p = .08$: People who had experienced at least one thrill, compared with those who had not, showed a bimodal pattern in their willingness to donate blood—a vast majority chose the highest and the lowest reaches of the scale (Table 4). Of course, whether this pattern was caused by the experience of thrills versus its absence, or by a third factor that also affected the occurrence of thrills, cannot be determined; we shall return to this issue. Suffice it to say that "emotionality" seems to be a good candidate for the third factor—for obvious reasons with regard to the probability of thrills, and because it may lead some "emotional" people to be fervent about helping, and others to be inordinately squeamish about blood, with the resulting high frequency of extreme ratings.

GENERAL DISCUSSION

The phenomenon of thrills or chills has attracted a certain amount of attention, mostly by researchers interested in the relationship between music and emotion (e.g., Blood & Zatorre, 2001; Goldstein, 1980; Panksepp, 1995; Rickard, 2004; Sloboda, 1991). The work that we report here differs in significant ways from, and extends, prior research. First, our experiments examined whether the occurrence of thrills that the par-

Table 4. Willingness to donate blood as a function of thrills

Experienced at least one thrill in Segment A or B	Willingness level			
	Low	Medium	High	Total
Yes	27 (36.00)	9 (12.00)	39 (52.00)	75 (100)
No	44 (29.93)	37 (25.17)	66 (44.90)	147 (100)
Total	71	46	105	222

Note. The low, medium, and high levels of willingness correspond to the 1–5, 6–9, and 10–13 regions of the 13-point self-rating scale. Numbers in parentheses indicate the percentage of the row total.

ticipants experienced in response to experimenter-selected (as opposed to participant-selected) pieces of instrumental classical music could be affected (primed) by prior aesthetic events. Second, these prior stimuli were in three different modalities (music, stories, architecture/paintings), which considerably broadened the investigation of the precursors of chills. Third, the antecedent events could themselves be expected to produce thrills, so that the possibility of the music-induced thrills being primed by the immediately preceding thrills elicited by the stimuli in the same and other modalities could be explored. Fourth, it could be calculated whether the initial self-ratings of "emotionality" were related to the likelihood of experiencing thrills. And fifth, the experiments examined whether or not the experience of chills makes a difference in the participants' subsequent mood, prosocial self-concept, and altruistic behavioral inclinations. The research was thus a multi-pronged attempt to explore the psychological significance of thrills, to investigate their role in the aesthetic-emotional, multi-stage, exposure→experience→self-evaluation stream, and to find out whether the thrills experience can be changed and whether it can change the experiencing person.

Even though considerable stimulus sampling was carried out and three groups of dependent measures used, this work is obviously subject to restrictions on generalization beyond these procedures and measures. The power of some χ^2 tests was admittedly low, but the null results were generally confirmed by χ^2 tests with a greater n and ANOVAs on continuous measures.

Experimental induction of thrills

In Experiments 1–3, about 35% of the participants reported at least one thrill in either Segment A or B. The 4'30"-long Rachmaninoff excerpt was heard in Segment B in 11 conditions and a total of 111 thrills were experienced by 43 people, or 0.57 thrills/min/person. This is comparable to Panksepp's participants' (1995, Study 2) highest rate of 0.50 thrills/min/person in response to a track from Pink Floyd's *Final Cut*. In short, our manipulations were successful in inducing thrills in a sizable proportion of participants.

The extent to which the "unadulterated" aesthetic stimuli (Segment A) from the musical, textual, and visual modalities were able (or not able) to induce thrills in Experiments 1–3 is shown in Figure 1 (black bars). These results should be viewed in conjunction with the two principal baseline (no Segment A) conditions in which 40% and 33% of the participants felt thrills while listening to Rachmaninoff and Haydn, respectively (Table 2). Excepting visual stimuli, the contrasts between pairs of stimuli in which one member was designated on theoretical grounds as the less potent control for the other were in the predicted direction or statistically sig-

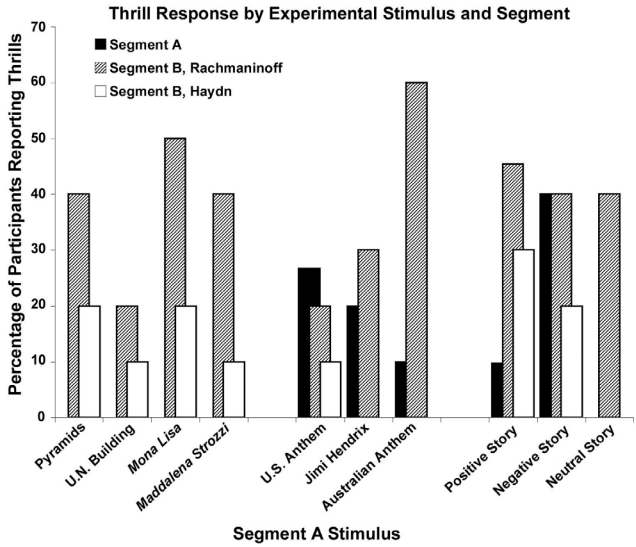

Figure 1. Percentage of participants reporting thrills as a function of experimental stimuli and segments. The absence of a black bar signifies that no thrills were reported to the stimulus in question during Segment A. The data are drawn from Tables 1 and 2.

nificant: U.S. anthem > Australian anthem; self-sacrifice stories > neutral story; and Rachmaninoff > Haydn.

In sum, thrills can be induced in the laboratory in at least two modalities, and in a predictable manner, by aesthetic stimuli chosen on theoretical grounds. With regard to music, the induction of thrills can be successful in participants from a general student population and without the participants listening to selections of their choice.

Antecedents of music-induced thrills

One of the key questions was whether thrills that were expected to be induced by the Rachmaninoff and Haydn compositions could be affected by prior exposure to various aesthetic stimuli. The findings were almost uniformly negative: Neither the qualitative aspects of the modalities of antecedent stimuli (i.e., their awe-inspiring, patriotic, and elevating attributes), nor their relative thrill-induction potency, had any augmenting effect on the thrills induced by Rachmaninoff and Haydn.

Contrast and "collative" variables. An interesting exception to the aforementioned conclusion was observed in Experiment 1. As expected for our UCSD sample, listening to the Australian anthem produced a smaller thrills reaction than listening to the U.S. anthem. However, when the participants next heard Rachmaninoff, those who had heard the Australian

anthem experienced significantly more and longer thrills than those who had heard the U.S. anthem (see Figure 1).

On the reasonable assumption that most, if not all, national anthems are mediocre musical compositions that affect exclusively the various countries' citizens (as a result of a lengthy process involving classical and operant conditioning, modeling, and indoctrination), one would expect that our American students would find the Australian anthem rather bland. When these people next encountered Rachmaninoff, they may have responded especially strongly because of the contrast in the amount of stimulation. "Collative" stimulus properties (Berlyne, 1971), such as surprisingness, complexity, and novelty, might play a part in such a contrast effect.

Emotional "draining." Another plausible explanation concerns people who heard the U.S. anthem. Listening to it and responding with chills, they became temporarily emotionally drained, so that Rachmaninoff had a feeble impact. The hydraulic metaphor simply suggests the possibility that there may be attentional, processing, and physiological limits to how many chills people can experience in a given time period. If so, is hearing one piece after another in quick succession more conducive to reaching the limit than listening to one longer piece? If thrills are in part a response to certain structural features of the music (Sloboda, 1991), and if in most compositions such features are spread over time to allow for thematic and harmonic development, then listening to different short pieces with a higher structural-event density may indeed cause the limit to be reached sooner. This is an interesting avenue for future research.

Cross-modal effects. A finding analogous to the one involving the U.S. and Australian anthems was obtained in Experiment 2. A significantly greater proportion of participants who had read the two self-sacrifice story versions reported thrills than did those who had read the bland story (Table 1 and Figure 1). However, when the three groups next listened to Rachmaninoff, people in the neutral-story conditions reported more and longer thrills than did the participants in the other two conditions (although this was not statistically significant; see Table 2). These suggestive results should be viewed in conjunction with another, admittedly weak, finding in Experiment 2: Participants who had read the two self-sacrifice stories subsequently experienced fewer and shorter thrills while listening to Haydn than did participants who had had no exposure to any stimulus before hearing Haydn (*ns*, Table 2).

Despite the large number of conditions, our designs do not make it possible to decide between the contrast and emotional-drainage explanations. They are applicable to different groups of participants and involve processes with opposite effects. Both may have been operative. This problem warrants further experimental investigation.

The second question regarding the antecedents of music-induced thrills

is whether their occurrence can be primed by the immediately preceding experience of thrills. The data show that feeling thrills tended not to be associated with their subsequent occurrence; this was true both within the music modality and cross-modally. Summing across the three experiments ($N = 171$), one finds that of the 21 participants who had experienced thrills in Segment A, only six (29%) also reported thrills in Segment B; and of the 150 people who had not experienced thrills in Segment A, 45 (30%) experienced thrills in Segment B. In this research, thrills simply did not prime thrills.

Self-ratings of "emotionality" and thrills. In the warm-up questionnaire, the participants responded on 13–point scales anchored by *agree completely* and *disagree completely* to two questions: "I react with a lot of emotion to the major events in my life" and "I 'feel' my emotions as a physical sensation." Across all participants in the three experiments who had had at least one opportunity to report thrills, the endorsement of the upper reaches on the first scale was significantly associated with experiencing thrills (the median split of ratings by yes/no thrills), $\chi^2(1, N = 211) = 4.29$, $p = .038$. The analogous test on the second scale was nonsignificant. It thus appears that the likelihood of a person experiencing thrills to music and other emotion-related and aesthetic stimuli is predictable from self-ratings on at least some "emotionality" scales.

Consequences of music-induced thrills

In this research, thrills, regardless of how they had been induced, had virtually no effect on the subsequently taken measures. Even the thrills induced by Rachmaninoff just prior to the collection of the dependent measures were inconsequential. Perhaps one might consider it somewhat unreasonable to expect an effect of the thrills experience on a statement of behavioral intention involving health issues, but there were also no effects on the less committing trait self-ratings; in fact, even the simple happy–sad mood scale did not capture any thrills-induced change in the participants.[4]

Thrills in aesthetic experience

Thrills are apparently a phenomenon bound to the present—a fleeting experience that is lateral to the chain of causally related emotional, aesthetic, cognitive, and behavioral events. However, there may be an important exception to this conclusion, which involves stimuli that induce complex cognitive operations simultaneously—and in addition—to chills and implicates the personal associative context. It has been suggested that *sublime* aesthetic stimuli produce the being-moved and aesthetic-awe reactions to which thrills can provide a physiological underpinning (Konečni, 2005). Although thrills may also have served as the physiological

concomitant of the cognitive impact of the stories in Experiment 2, these aesthetic stimuli may have not been sufficiently powerful to produce the mood and behavioral aftereffects postulated for the sublime stimuli by the aesthetic-trinity model.

Such considerations may help reconcile the absence of an effect of music-induced chills on mood in the present work with the statement describing chills as "intensely pleasurable responses to music" that one finds in the very title of the influential article by Blood and Zatorre (2001; cf. Krumhansl, 2002). Unlike our participants, those in the Blood-Zatorre experiment were musicians; furthermore, they had been "selected on the basis of their reports of frequent, reproducible experiences of chills in response to certain pieces of music" (p. 11818). Also unlike our participants, each of theirs "selected one piece of music [instrumental, classical genre] that consistently elicited intensely pleasant emotional responses, including chills" (p. 11818); for each participant, a 90-s excerpt, "including the section that elicited chills" (p. 11819), was selected for PET scanning. Such facts suggest that Blood-Zatorre participants, unlike many of ours, were not simply experiencing thrills but were likely to have reached, in the terminology of the aesthetic-trinity model, the more profound state of *being moved*.[5]

The first chord of their often-heard piece may have acted as a classically conditioned stimulus in the induction of the Blood-Zatorre (2001) participants' thrills. For many people, their national anthem may have such an effect. As Goldstein wrote (1980, p. 127), "[e]ven imagining these [powerful thrill-eliciting] stimuli can be effective." The entire personal associative context of the musical piece may be condensed as a classically conditioned stimulus for thrills induction in a particular person.

The implication of considering jointly the work we report here and that of Blood and Zatorre (2001), in terms of participant recruitment, procedures, and results, is that thrills on their own may be ephemeral and inconsequential, but that they sometimes may accompany, and act as a physiological support for, more profound aesthetic responses. Thrills may be elicited in people in general and with stimuli not of their choice, but in order to obtain more powerful effects and more profound states—such as being moved—one must resort to special populations and procedures or find a way of exposing research participants to sublime stimuli—rare, beautiful, colossal, and rich in personal meaning.

Notes

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Correspondence about this article should be addressed to Vladimir J. Konečni, Department of Psychology, University of California at San Diego, La Jolla, CA 92093-0109 (e-mail: vkonecni@ucsd.edu). Received for publication April 15, 2006; revision received June 29, 2006.

1. The (Romantic) Rachmaninoff excerpt was one of the most thrill-inducing in the pretesting that also showed the (Viennese Classical) Haydn excerpt to be significantly less potent in this regard. The Haydn was used in a few key conditions primarily as a generalization test for the potential priming power of the U.S. anthem.

2. The method chosen for reporting thrills was part of a concerted effort to make the participant's listening situation as unencumbered, natural, and authentic as possible. In this regard, it was found superior in pretesting to pressing a button or a computer key.

3. The psychological laboratory has great difficulty capturing rare and momentous events and responses. As Ekman (2003, p. 195) put it, "There have been virtually no scientific studies of wonder; think how difficult it would be to arrange for wonderment to occur in a laboratory."

4. Other measures, beyond the scope of the present research, may indeed fare differently. For example, the experience of thrills may increase the liking for the thrills-inducing aesthetic stimulus.

5. Indeed, it is possible that the Blood-Zatorre (2001) participants, unlike many of ours, experienced a post-thrills improvement in mood; unfortunately, post-treatment mood data were either not collected or not reported.

References

Berlyne, D. E. (1971). *Aesthetics and psychobiology.* New York: Appleton Century.

Blood, A. J., & Zatorre, R. J. (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences (PNAS) Biological Sciences, 98,* 11818–11823.

Brown, J. D., & Mankowski, T. (1993). Self-esteem, mood, and self-evaluation: Changes in mood and the way you see you. *Journal of Personality and Social Psychology, 64,* 421–30.

Ekman, P. (2003). *Emotions revealed.* New York: Holt.

Fried, R., & Berkowitz, L. (1979). Music that charms . . . and can influence helpfulness. *Journal of Applied Social Psychology, 9,* 199–208.

Goldstein, A. (1980). Thrills in response to music and other stimuli. *Physiological Psychology, 8,* 126–129.

Greene, G. (1948). The heart of the matter. London: William Heinemann.

Haidt, J. (2000). The positive emotion of elevation. *Prevention & Treatment, 3,* 1–4.

Juslin, P. N., & Sloboda, J. A. (Eds.). (2001). *Music and emotion.* Oxford: Oxford University Press.

Keltner, D., & Haidt, J. (2003). Approaching awe, a moral, spiritual, and aesthetic emotion. *Cognition and Emotion, 17,* 297–314.

Konečni, V. J. (1995). Interactive effects of music and visual art in different emotional states. In I. Gorlova, V. M. Petrov, & Y. Rags (Eds.), *Proceedings of the international conference on "The human in the world of art: Informational aspects."* Novorossijsk, Russia: Moskva/Krasnodar Science Publishers.

Konečni, V. J. (2003). Review of *Music and emotion: Theory and research. Music Perception, 20,* 332–341.

Konečni, V. J. (2005). The aesthetic trinity: Awe, being moved, thrills. *Bulletin of Psychology and the Arts, 5,* 27–44.

Konečni, V. J. (2007). *On the relationship between music and emotion.* Manuscript submitted for publication.

Konečni, V. J., Brown, A., & Wanic, R. A. (in press). Comparative effects of music and recalled life-events on emotional state. *Psychology of Music.*

Konečni, V. J., & Sargent-Pollock, D. (1976). Choice between melodies differing in complexity under divided-attention conditions. *Journal of Experimental Psychology: Human Perception and Performance, 2,* 347–356.

Krumhansl, C. L. (2002). Music: A link between cognition and emotion. *Current Directions in Psychological Science, 11,* 45–50.

Panksepp, J. (1995). The emotional source of "chills" induced by music. *Music Perception, 13,* 171–207.

Panksepp, J. (1998). *Affective neuroscience: The foundations of the human and animal emotions.* New York: Oxford University Press.

Rickard, N. S. (2004). Intense emotional responses to music: A test of the physiological arousal hypothesis. *Psychology of Music, 32,* 371–388.

Scherer, K. R., & Zentner, M. R. (2001). Emotional effects of music: Production rules. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and emotion.* Oxford: Oxford University Press.

Sloboda, J. A. (1991). Musical structure and emotional response: Some empirical findings. *Psychology of Music, 19,* 110–120.